Proposed Michigan K-12 Science Standards and Climate Change

Summary
Michigan's proposed K-12 Science Standards, currently under review by the State Board of Education, were designed by scientists, engineers, educators, business leaders, and other experts to address the relevant expectations for students on science practices and content to be career and college ready. These ***standards include student performance expectations centered on the core idea of climate change***, among other topics. An analysis of these standards reveals the following:

- ***The standards do not specifically change the content on this topic*** that students are expected to know from Michigan's current science standards. Rather, the ***proposed standards change the way that students are expected to interact with this content*** on a broader scale, focusing on investigating scientific phenomena, analyzing data and developing models to understand scientific processes of our atmosphere, and impacts on a variety of phenomena.
- Additionally, ***proposed standards include engineering practices*** that encourage students to explore design strategies and problem solving approaches, which teachers could apply to climate change and related topics.
- Current standards address this same content by primarily asking students to describe and explain content details, rather than investigating the topic. The current standards are written to a lower depth of knowledge and understanding of the content, and include fewer expectations that require higher-order thinking or problem solving.
- The current and proposed standards also include references to interdependent factors in the environment or in ecosystems that include human interaction. These are often interpreted by some as climate change standards, but they do not actually address climate change specifically. Critics' misconceptions about these as equivalent topics often leads to confusion on arguments about climate change.

Overview
The proposed Michigan K-12 Science Standards are based upon the Framework for K-12 Science Education, which was developed in 2011 by the National Research Council (an arm of the National Academies of Science). The development process for the standards involved K-12 educators, state science officials, scientists, engineers, business leaders and university faculty members. As a lead state partner in the standards development, Michigan has played an active role throughout the review and revision process. The standards have undergone numerous lead-state and all-state reviews as well as two public comment periods (in May 2012 and January 2013).

One of the major challenges of the development of the standards was to create student performance expectations that should be focused on a limited number of core ideas. A core idea in K-12 science was identified as having disciplinary significance and explanatory power, as being generative, relevant to peoples' lives, and usable from K to 12. Climate change was identified as one of these core ideas. It was determined that it is important for the science of

climate change to be taught in order for students to be able to make scientifically informed decisions about climate change.

In understanding what standards provide for our schools, it is important to reiterate that a standard is not the curriculum that students will see in school. A standard defines what the students should know and be able to do, and thus may see on assessments such as the new M-STEP (or previously, Michigan Merit Exam). Because Michigan is a local control state, the curriculum that students see in school is determined by the local school district and school board. Each school district determines how its students are to meet the standards that are set forth by the state. This relates to not only climate change, but to all of the disciplinary core ideas developed for the Framework for K-12 Science Education, in that it is up to local school districts, public school academies, and their school boards to determine the resources and instruction that will help students achieves the performance expectations.

Climate change is not a new concept to Michigan's science standards. Michigan's current Grade Level Content Expectations and High School Content Expectations address content specific to climate change, research on climate change, and impacts of climate change. The current standards that address these topics are listed at the end of this document.

An analysis of Michigan's existing content standards on topics of climate and climate change reveals that students are primarily expected to describe or explain concepts or phenomena related to climate change. While these standards require some understanding of the content, they do not necessarily reflect a depth of knowledge or understanding of concepts that is required to actually question aspects of the phenomena related to climate change. Of the 27 current standards addressing climate change that were adopted by Michigan in 2006, 20 ask students to identify, describe, or explain concepts or content, and very few ask students to investigate a particular concept, either on their own or through possible relevant data sources.

The changes that are proposed around climate change as a topic address the depth of understanding, student interaction with content, and the practices of scientific research and investigation, along with problem solving through engineering and design practices. Twelve (12) of the student performance expectations in the proposed Michigan K-12 Science Standards address topics related to climate change. All of these expectations ask students to interact with concepts in a different way, including using data and models to explore concepts and investigate claims. While some standards do ask students to be able to describe phenomena, they do so in ways that require students to analyze and synthesize information from multiple sources, rather than just repeating concepts that might have been addressed through a single source of information, such as a textbook or web site. The focus on these analysis and information practices also develops a stronger understanding of data analysis skills and general technological competencies for analyzing and representing data. These efforts will require educators to be able to access and utilize data and computational technologies in ways that are not often practiced today.

Some question the inclusion of climate change and climate science at all in K-12 schools, stating a lack of evidence to support theories. However, the scientific community at large has addressed such challenges in a variety of statements, including the following from the American Meteorological Society:

"Climate change science is firmly rooted in peer-reviewed scientific literature; as science, it is as sound as other subjects such as earthquakes and the solar system.... Climate literacy in the next generation of U.S. citizens will ensure a firm foundation of knowledge and discourse as society faces decisions on how to best deal with a changing climate.

There are also often responses to standards addressing human interaction with the environment. These are often confused to be standards related to specifically to climate change by some individuals or groups that challenge the inclusion of standards related to climate change for K-12 students. However, a review of these standards reveals that many address issues of "environment" and "ecosystems," which are often part of a broader political debate about certain human activities, but are not necessarily related to climate change specifically, and these connections are not explicitly stated in the proposed standards. This is common mis-interpretation among non-scientists or individuals who have read the standards out of context. In order to address these misplaced assumptions, the MDE will work with other state offices and organizations that focus on various environmental issues to develop guidance for educators and the public around these issues.

Current and Proposed Standards

To better understand the differences and expectations around climate change, the following table identifies the current and proposed standards on these (and related) topics. Michigan's current Grade Level and High School Content Expectations addressing Weather and Climate, Oceans and Climate, and Climate Change are identified on the left. The performance expectations for the Disciplinary Core Ideas ESS2D Weather and Climate and ESS3D Global Climate Change as listed in the proposed standards are identified on the right. Both utilize the coding citations of these documents for easy reference, and are organized by grade level bands.

Elementary School (Grades K-5)

Michigan's Current Standards (GLCE's and HSCE's) on climate and weather topics	**Proposed Michigan K-12 Science Standards on climate and weather topics**
E.ES.01.21 Compare daily changes in the weather related to temperature (cold, hot, warm, cool); cloud cover (cloudy, partly cloudy, foggy); precipitation (rain, snow, hail, freezing rain); wind (breezy, windy, calm). E.ES.01.22 Describe and compare weather related to the four seasons in terms of temperature, cloud cover, precipitation, and wind. E.ES.01.23 Describe severe weather characteristics. E.ES.01.24 Describe precautions that should be taken for human safety during severe weather conditions (thunder and lightning, tornadoes, strong winds, heavy precipitation). E.ES.01.31 Identify the tools that might be used to measure temperature, precipitation, cloud cover, and wind. E.ES.01.32 Observe and collect data of weather conditions over a period of time.	K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. 3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

Middle School (Grades 6-8)

Michigan's Current Standards (GLCE's and HSCE's) on climate and weather topics	Proposed Michigan K-12 Science Standards on climate and weather topics
E.ES.07.71 Compare and contrast the difference and relationship between climate and weather. E.ES.07.72 Describe how different weather occurs due to the constant motion of the atmosphere from the energy of the sun reaching the surface of the Earth. E.ES.07.73 Explain how the temperature of the oceans affects the different climates on Earth because water in the oceans holds a large amount of heat. E.ES.07.74 Describe weather conditions associated with frontal boundaries (cold, warm, stationary, and occluded) and the movement of major air masses and the jet stream across North America using a weather map.	MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. MS-ESS3-5. Ask questions to determine the factors that have caused the rise in global temperatures over the past century.

High School (Grades 9-12)

Michigan's Current Standards (GLCE's and HSCE's) on climate and weather topics	Proposed Michigan K-12 Science Standards on climate and weather topics
E4.2A Describe the major causes for the ocean's surface and deep water currents, including the prevailing winds, the Coriolis effect, unequal heating of the earth, changes in water temperature and salinity in high latitudes, and basin shape. E4.2B Explain how interactions between the oceans and the atmosphere influence global and regional climate. Include the major concepts of heat transfer by ocean currents, thermohaline circulation, boundary currents, evaporation, precipitation, climatic zones, and the ocean as a major CO_2 reservoir. E4.2c Explain the dynamics (including ocean-atmosphere interactions) of the El Niño-Southern Oscillation (ENSO) and its effect on continental climates. E4.2d Identify factors affecting seawater density and salinity and describe how density affects oceanic layering and currents. E4.2e Explain the differences between maritime and continental climates with regard to oceanic currents. E4.2f Explain how the Coriolis effect controls oceanic circulation. E4.r2g Explain how El Niño affects economies (e.g., in South America). *(recommended)* E5.4A Explain the natural mechanism of the greenhouse effect, including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone). E5.4B Describe natural mechanisms that could result in significant changes in climate (e.g., major volcanic eruptions, changes in sunlight received by the earth, and meteorite impacts).	HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. HS-ESS2-4. Use a model to describe how the variations in the flow of energy into and out of Earth systems results in changes in climate. HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth systems and life on Earth. HS-ESS3-5. Use a computational model to make an evidence-based forecast of the current rate of global or regional climate change and associated impacts on other Earth systems. HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

E5.4C Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years. E5.4D Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity of the biosphere). E5.4e Based on evidence from historical climate research (e.g. fossils, varves, ice core data) and climate change models, explain how the current melting of polar ice caps can impact the climatic system. E5.4f Describe geologic evidence that implies climates were significantly colder at times in the geologic record (e.g., geomorphology, striations, and fossils). E5.4g Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat-trapping capacity. E5.r4h Use oxygen isotope data to estimate paleotemperature. *(recommended)* E5.r4i Explain the causes of short-term climate changes such as catastrophic volcanic eruptions and impact of solar system objects. *(recommended)* E5.r4j Predict the global temperature increase by 2100, given data on the annual trends of CO_2 concentration.	